THE POTENTIAL OF BRICK WASTE AS FINE AGGREGATE REPLACEMENT IN CONCRETE PRODUCTION

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ABSTRACT

This study is focusing on determining the suitability of brick waste as the fine aggregate replacement in concrete production. The fine aggregate in concrete was replaced by using brick waste with various different proportions The performance of concrete with brick waste in the mixture were compared with the conventional concrete with grade C25. 55 cubes and 10 beams including control samples were prepared for this study. The water cement ratio 0.45 were standardize in all concrete samples. Brick waste from construction were crushed to be added in concrete mixture to replace fine aggregate with different proportions of 0%, 5%, 10%, 15%, and 20%. Four types of laboratory tests; slump test, compressive strength test, flexural test and water penetration test were conducted to achieve the objective of the study. The results obtained from the laboratory test shows that the replacement proportion 10% of clay brick waste in concrete were enhancing the strength and durability of the concrete. The workability and water penetration of the concrete also were following the specified standard. Therefore, it is proven that the replacement by proportion of brick waste in concrete production is suitable.

ABSTRAK

Kajian ini memberi tumpuan untuk menentukan kesesuaian sisa bata sebagai pengganti agregat halus dalam pengeluaran konkrit. Agregat halus di dalam konkrit telah digantikan dengan menggunakan sisa bata dengan pelbagai perkadaran yang berbeza .Prestasi konkrit dengan sisa bata di dalam campuran dibandingkan dengan konkrit konvensional dengan gred C25. 55 kiub dan 10 rasuk termasuk sampel kawalan telah disediakan untuk kajian ini. Nisbah 0.45 simen air telah diseragamkan dalam semua sampel konkrit. Sisa bata daripada pembinaan telah dihancurkan yang akan ditambah di dalam campuran konkrit untuk menggantikan agregat halus dengan perkadaran yang berbeza 0%, 5%, 10%, 15%, dan 20%. Empat jenis ujian makmal; ujian runtuhan kon, ujian kekuatan mampatan, ujian lenturan dan ujian penembusan air ujian telah dijalankan bagi mencapai objektif kajian. Keputusan yang diperolehi daripada ujian kekuatan mampatan telah diambil pada 7, 14 dan 28 hari. Keputusan kajian telah menunjukkan bahawa penggantian mengikut bahagian sisa bata dalam konkrit sebanyak 10% telah meningkatkan kekuatan dan ketahanan. Keblehkerjaan serta penembusan air juga memenuhi standard piawai yang ditetapkan. Oleh itu, adalah terbukti bahawa penggantian mengikut bahagian sisa bata dalam pengeluaran konkrit adalah sesuai.

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%	Percentage
°C	Degree Celcius
F	Load at the Fracture Point
L	Length of Span
b	Width
d	Thickness

LIST OF ABBREVIATION

ASTM	American Standard Test Method
B.C	Before Century
BS	British Standard
CaO	Calcium Oxide
Fe_2O_3	Aluminium Oxide
JKR	Jabatan Kerja Raya
OPC	Ordinary Portland Cement
PCA	Portland Cement Association

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Fine aggregate can be defined as aggregate that pass the 3/8" sieve and almost entirely passing the No. 4(4.76) sieve and predominantly retained on the No.200 (74 micron) sieve (ASTM 125) (American Portland Cement, 2013). Fine aggregate is one of the materials for concrete production. It consists of natural sand or crushed stone. In concrete, fine aggregate acts as the filler, to fill voids between the coarse aggregate and act as a workability agent. Sand particle is rounded shape and smooth surface while crushed stone is more angular and rough surface. The advantage of using sand as the fine aggregate in concrete is it provide more workable concrete compared to using crushed stone. However, crushed stone that have a rough surface provide a stronger bond between the coarse aggregate and hence contribute to a higher strength of concrete.

The resources of aggregate are from natural sources that are from quarrying activity. Due to the high demand of aggregates as a result from increasing activity in construction sector at the last decades, an environmental issue has been arise that is the increase of exploration of the natural resources from the continuous activity of quarrying to fulfil the demand of the raw materials. The construction activity by nature is harmful to the environment

(Vivian, 2005). Besides contribute to depletion of natural sources, construction activity also caused pollution from the activity of manufacturing the materials that is harmful to the human and other living things.

The constructions materials' costs were increasing rapidly from the last ten years. This is due to increment of production costs and transportation costs of raw materials for manufacturing purposes. Proper waste management in construction is the best solution for that problem. Utilizing and recycling the waste material can help to reduce those costs by minimizing wastage and at the same time can maximize the energy usage. Gao (2001), suggested that the uses of energy for production of material can be reduced by about 25% if recycled materials were used, compared conventional production in Japan. It is important to maximize the uses of waste material in term of energy and cost savings.

The major problem from the construction activity is the improper way of managing the construction waste. Year by year, the amount of construction wastes that were dumped at the land filling area is increasing. This will reduce the storage at the disposal area. The land filling area is occupied by construction wastes. Therefore it is essential to produce and carry out a functional idea on how to reduce the wastes. One of the ways is by recycling the wastes for other usage. The main idea is to substitute or reduce the materials usage for conventional construction in construction sector (Pappu, 2006). The brick waste is a potential material to be used as an alternative for fine aggregate in concrete production. Hence this study is focusing about the potential of the brick waste as the fine aggregate replacement in concrete production.

1.2 PROBLEM STATEMENT

Construction waste is one of the waste that causing major problem in handling them for many of the developed countries nowadays. It has been recognized that during the last decades, the wastes from construction is increasing in volume from year to year. The increasing of waste product from year to year is contributing to the decreasing of storage at the disposal sites, because the wastes are dump to the land filling area. According to Ferguson (1995), only 50% of the wastes generated in UK are mainly construction waste and debris. Therefore, larger disposal area is needed to ensure there is enough space for all the wastes.

Besides, the other problem is the impact to the environment. The material for construction such as brick waste has been produced from quarrying activity. The activity can harm the environment due to continuous process of land stripping. Therefore, there is a need to strategize a way that can minimize the wastes and at the same time to reduce the demand of the resources from quarrying activity. One of the ways is by recycling the waste products to be used again for other purpose. For example, by reusing brick waste for replacing fine aggregate in concrete production.

1.3 OBJECTIVE OF STUDY

Due to the problems that arise, recycling the construction waste is the best way to reduce it. One of the construction materials that can be recycled is brick waste, to be used in concrete production. Therefore, the aim of this study is to investigate the use of brick waste as the filler in concrete production. Three objectives have been listed as shown below to achieve the aim of this study:

- To determine the suitability of brick waste as the fine aggregate replacement in concrete production.
- To compare the performance of concrete with the control concrete.

1.4 RESEARCH METHODOLOGY

The objectives of this study were determined and achieved by carrying out the following tests:

i. To determine the suitability of brick waste as the fine aggregate replacement in concrete.

- Water penetration test
- Slump test

i. To compare the performance of concrete with the control concrete.

- Compressive strength test
- Flexural test

1.5 SCOPE OF STUDY

The scopes of the study were covering these types of tests that were conducted to the concrete samples:

- Compressive strength test

  To determine the compressive strength of concrete cubes at the 7^{th}, 14^{th} and 28^{th} day of the casting period by conducting compressive strength test. The value obtained from the test must be higher than the standard specified strength for the concrete cube to pass.

- Water penetration test

  The water penetration test is to measure the depth of water penetration of the concrete cube to compare with the control concrete. This test is important for us to know the minimum concrete cover for the reinforced concrete to prevent from corrosion happened.

- Slump test

  This test is to measure the workability of fresh concrete before being poured in cubes and beam. The design slump was 75 ± 25 mm.

- Flexural test

  Test for determining the tensile strength of the concrete beam and comparing the result of the concrete with alternative material with the control concrete.

1.6 SIGNIFICANCE OF STUDY

Concrete is one of the most important construction materials that had been used widely in the world. There are many researches and studies that had been carried out to improvise the quality of concrete production and to create various types of concrete that will be used for different purposes according to its suitability. Many researches had been conducted to enhance the quality or properties of the conventional concrete by mixing or adding other materials into the natural conventional concrete. For this study, brick waste is used as the filler to replace sand or fine aggregate in the conventional concrete. The purpose of this study is to determine the suitability of brick waste as the fine aggregate replacement material in concrete production and to compare the performance with the conventional concrete production. The study is important because the proposed material to replace sand is waste product from construction. If brick waste is suitable, it can be used in concrete production. This will reduce the waste material from construction as brick waste can be recycled for concrete production purposes. Besides, it can cut down the uses of natural sand that is produced from quarrying process which is non-environmental process and harmful to environment. The concrete's production cost can be reduced because the alternative material is waste material that is low in cost.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is explaining theoretically about the definition of concrete, materials that have been used to produce the conventional concrete, additional material that is added in concrete and the past researches that were related with this topic. The tests that were conducted also were explained in this chapter.

2.2 CONCRETE

Concrete can be defined as the mixture of fine and coarse aggregates, cement and water which will set, and harden, to give a strong and durable product (Cement Concrete and Aggregate Australia, 2004). According to Portland Cement Association (PCA, 2010), concrete is basically a mixture of aggregates and paste. The aggregates are sand and gravel or crushed stone; the paste is water and Portland cement. The mixing ratio of the materials will determine the strength or the grade of the concrete produced. Concrete is the product that is produce from the combination of aggregate, with sand, water, cement and other mixing agent (Warner, et. al, 1998). Theoretically, concrete

mixture was purposely designed to determine the optimum quantity in the mixture and also following the specification.

2.2.1 Conventional-Modern Concrete

Concrete is the material that is useful in the construction work. It can harden in whether moisture or wet and this condition help in the concrete curing process. The amount of each material (i.e. cement, water and aggregates) affects the properties of hardened concrete. In conventional modern concrete, the proportion of the materials in concrete must follow the specified ratio to produce the strength needed. The strength of concrete is depending on the mixing ratio. Table 2.1 shows the concrete mixing ratio according to their uses.

Table 2.1: Mixing ratio of concrete

Mixing ratio	Uses
1 : 5 : 10	Base for retaining wall for hard soil
1 : 3 : 6	Concrete slab
1 : 2 : 4	Reinforced concrete for column, beam and etc.

Among the types of concrete with applications:

1. Light weight concrete

- Self weight of light weight concrete varies from 300 to 1850 kg/m^3
- Light weight concrete has low thermal conductivity.
- Helps reduce the dead load.

2. High density concrete

- Density concrete varies from 3360 kg/m3 to 3840 kg/m^3.
- Uses heavy natural aggregates
- High modulus of elasticity, low thermal expansion, and creep deformation.

3. Mass concrete

- Design based on durability, economy, and thermal action.
- Measures should be taken where cracking due to thermal behaviour.

2.2.1.1 Cement

Cement or specifically Ordinary Portland Cement (OPC) is the basic materials for concrete. Cement is the binder that binds all the component materials that is aggregates to form a rigid body. Cement undergo a chemical reaction process after is mixed with water during concrete mixing process. It fills the void between the materials and makes the body rigid. There are many types of cement that was manufactured besides Ordinary Portland Cement such as:

- Rapid Hardening Portland cement
- Low Heat Portland cement
- Sulphate Resisting Portland cement

Portland cement is made up from mixture of calcium oxide (CaO), silicon dioxide (SiO_2), iron oxide (Fe_2O_3) and aluminium oxide (Al_2O_3). The chemical reaction of cement with water is called hydration process. Cement is a material that has the adhesion and cohesion properties. Figure 2.1 below shows the different types of Portland Cement and Figure 4.2 shows the example of Ordinary Portland Cement.

Figure 2.1: Different types of portland cement

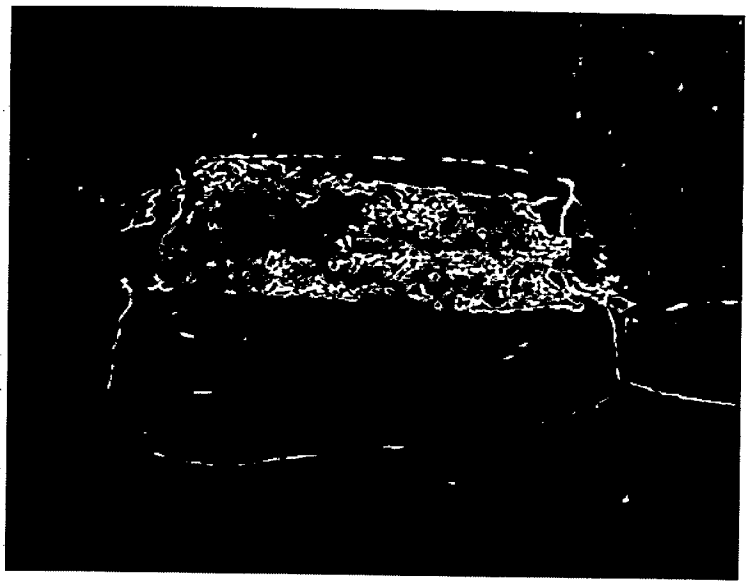

Figure 2.2: Ordinary portland cement

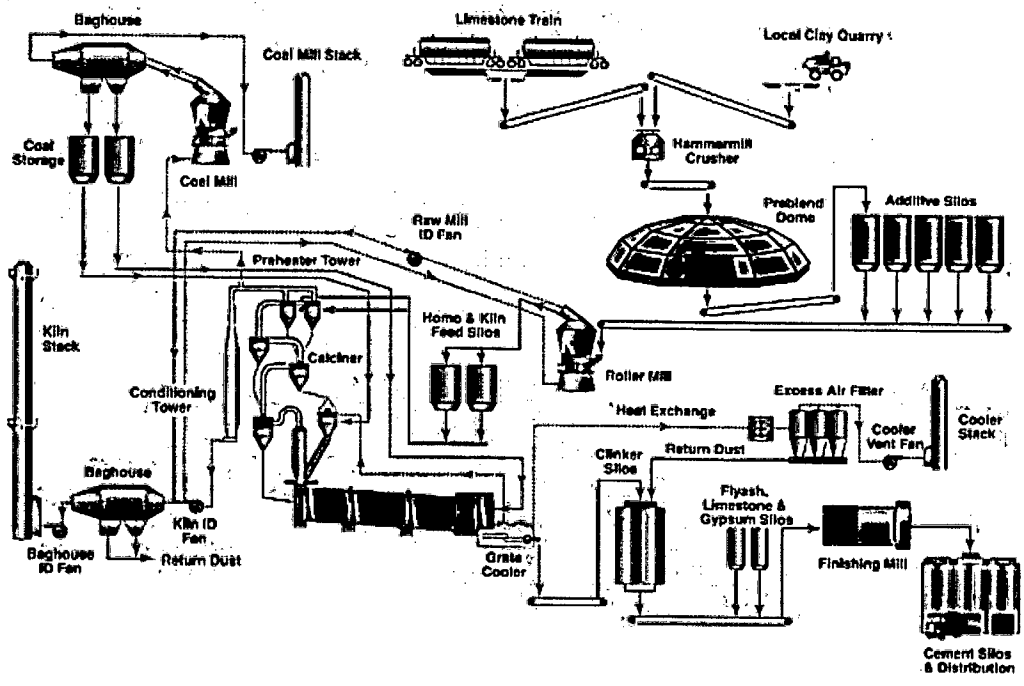

Figure 2.3: Process of manufacturing cement

2.2.1.2 Water

Water is the main sources to produce concrete. Water acts as the chemical reactants for cement to bind the aggregates in concrete mixing process (Neville, 2005). Besides, water is also use to wash the aggregate and curing process of concrete. The water that is use in concrete mixing must be free from any impurities such as organic material like salt or alkali. Water that contains impurities will affect hardening process, strength, density and durability of concrete. Concrete will become friable, change in colour and corrosion happened (Blackledge, 1970). There are no specific standards for water in concrete mixing. However the suitability of water is determined by comparing the setting time between concrete with distilled water and sample concrete with questioned water. If the different in setting time does not exceed 30 minutes and the strength is not reduced more than 20% therefore the water is considered suitable (Ezahtul, 2010).

Water cement ratio (w/c) is among the factor that determined the concrete strength. The lower (w/c) ratio will produce the stronger concrete, while the higher (w/c) ratio will produce lower strength concrete. The amount of water use in concrete will determine the strength, durability and also the water absorption of concrete. If more water is use, the strength and rigidity of concrete will decrease. However, if less water is use then the hydration process will not occur properly (Taylor, 1977).

2.2.1.3 Aggregate

Stone and sand are the basic materials that have been use in building structure since thousand years ago. Since the Roman empires, crushed aggregate is use to construct roads and buildings. This leads to the findings of concrete technology that producing many of famous buildings that are still exist until today (Robinson et. al, 2001). Today, they are the important materials to produce concrete. Sixty to eighty percent of concrete content is aggregate. Aggregate is cheaper than cement and that is why the usage of aggregate in concrete is maximum.

The material chosen for the specific concrete mixing is very important as the behaviour is affecting the strength, durability, mixing ratio and affects economically to produce the concrete. For economically purposes, it is very beneficial to use the aggregate from the nearby sources (Saimi, 2009). Aggregate is available whether from river or quarry. The aggregate from river is rounded shape while from quarry is sharp.

Figure 2.4: Aggregate from quarrying activity

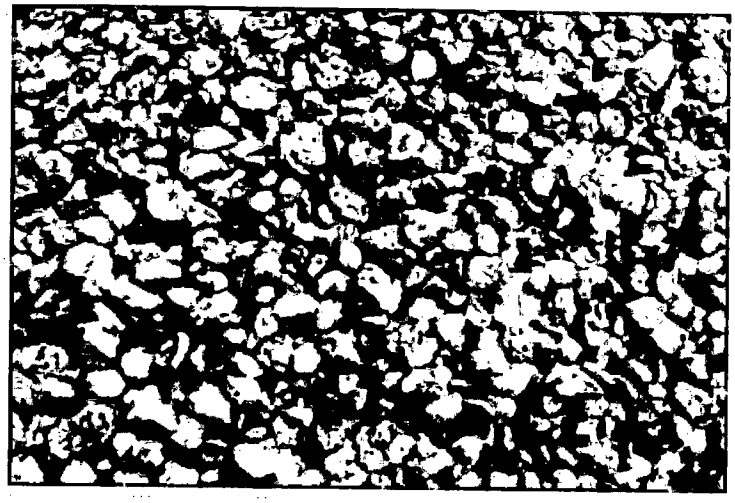

Figure 2.5: Aggregate from river

Aggregate is graded according to its size to produce concrete with high strength and durability. It can be classified into two categories:

I. Coarse aggregate: The size distribution varies between 50 mm to 5 mm. This type of aggregate can be obtained from quarry where the big stone is crushed and is grading according to specified sizes.

II. Fine aggregate: Size does not exceed 4.76 mm. Available from mining sand, river sand and also crushed stone.

2.2.1.4 Coarse Aggregate

Coarse aggregate is the material that is produce from explosion process and is crushed with crusher machine. Aggregate can be obtained from natural sources either in the form of rock which is crushed to obtain the size needed. The origin of natural aggregate can be classified into three categories:

I. Sedimentary rock: For thousand years, the earth is washed away by wind and water and layer of layer of eroded earth is deposited on top of each. These layers are pressed until the bottom layer was slowly turned into rock.
II. Metamorphic rock: Rocks that have morphed into another kind of rock. These rocks once sedimentary or igneous, but were heated due to tons of pressure and caused them to change.
III. Igneous rock: Called fire rocks and formed either underground or above ground. It is formed when magma, become trapped in small pockets and when slowly cooled, the magma becomes igneous rocks.

2.2.2.5 Fine Aggregate

Fine aggregate or sand is produced by process of crushing rock and minerals that forming small particles. In geological terms, fine aggregate is the small granular particle with diameter 0.075 mm to 2 mm. It fills the void between coarse aggregate to form a strong bond (Nelson et. al, 2008).

Types of fine aggregate are as below:

I. River sand
II. Mining sand
III. Crushed stone